A REVIEW OF *TEMNOSEWELLIA* (PLATYHELMINTHES: TEMNOCEPHALIDA) ECTOSYMBIONTS OF *CHERAX* (CRUSTACEA: PARASTACIDAE) IN AUSTRALIA

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New species are described and existing species reviewed of *Temnosewellia*, worms living ectosymbiotically on parastacid crayfish, *Cherax* spp., in Australia. ❐ *Temnosewellia, Cherax, Australia, ectosymbionts, crayfish.*

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Temnocephalida are dalyellioid rhabdocoels found as ectosymbionts, especially on freshwater crustaceans; they are characterised by a syncytial epidermis divided into a series of plates and a tendency to lose locomotory ciliation (Cannon & Joffe, 2001). Cannon (1986) recognised three families, Scutariellidae from prawns in Europe and Asia, the monotypic Actinodactylellidae from burrowing crayfish from southern Australia and the Temnocephalidae — a large and diverse family with Gondwanan associations. Sewell & Cannon (1996) resolved the position of controversial *Didymorchis*, i.e. in the Temnocephalida and within the Didymorchidae Bresslau & Reisinger, 1933. Cannon & Joffe (2001) also recognised Diceratocephalidae to include *Diceratocephala* and *Decadidymus*, each with two anterior tentacles.

By far the largest and most diverse family, Temnocephalidae, was first recorded in Australia in 1888 with *Temnocephala fasciata* Haswell, 1888 and *T. minor* Haswell, 1888 from the crayfish *Astacopsis serratus* (Shaw, 1794) and *A. bicarinatus* Gray, 1845, respectively. Today these crayfish are known to be several species, respectively in the genera *Euastacus* and *Cherax*. Haswell (1893) added temnocephalans from *A. bicarinatus* (i.e. *Cherax*), viz. *Temnocephala dendyi* Haswell, 1893 and *Craspedella spenceri* Haswell, 1893. Cannon & Sewell (1995) reviewed *Craspedella* adding new species and genera and recognising the subfamily Craspedellinae. With the exception of *Dactylocephala* from Madagascar which shows some differences (Cannon & Sewell, 2001), the remaining genera recorded within the Temnocephalidae, viz. *Temnocephala*, *Temnohaswellia*, *Temnomonticellia*, *Notodactylus*, *Achenella* and *Craniocephala* all display a similar facies and may be assigned confidently to the subfamily Temnocephalinae. The largest genus, *Temnocephala*, has species found on a wide variety of hosts. Recently, Damborenea & Cannon (2001) reviewed members of this genus from the Neotropics and concluded that the Australian representatives should be separated as *Temnosewellia*. Here we review *Temnosewellia* from *Cherax* spp. crayfish in Australia.

Collection and processing of crayfish and worms and morphological terminology follow Cannon & Sewell (1995). All worms were highly mobile on crayfish, and unless otherwise stated, worms were recorded as collected on the surface of the crayfish exoskeleton. Several species of worms were commonly found in the branchial chamber of their crayfish hosts, but none were located there exclusively.

Recognition that the cirrus is a most effective discriminator of species has led to taxonomic descriptions that are more succinct than in previous reports (Cannon & Sewell, 1995; Sewell & Cannon, 1998). In addition, many of the specimens we examine here were collected prior to our adoption of improved techniques requiring the use of live worms, i.e. the use of de Faure's fluid to elucidate the structure of the cirrus, and the use of silver nitrate to examine the epidermal mosaic (Cannon & Sewell, 1995; Sewell & Cannon, 1998).

TERMINOLOGY AND MEASUREMENTS

Specimen data are listed in the order: QM registration number; specimen/slide preparation details (in parentheses); host scientific name; locality details; date collected; collector(s); histological fixation/staining procedures. Full registration details are provided for each holotype specimen and for each new locality. For all subsequent specimens listed in the Materials

section (including paratypes), the QM registration number and specimen/slide preparation details are provided, followed by only those data which are different from that of the preceding registration. Discrete blocks of registration data are separated by semicolons. Specimens recorded in the Materials section, other than type material, are grouped by crayfish host, then Australian State.

Unless otherwise stated, measurements provided for soft structures are taken only from the taxonomic type series and those of the cirrus from special cirrus preparations. Descriptions of the cirrus refer to the inverted state of the organ and exclude fine details of the introvert spines. All measurements were made in microns (µm) with the aid of a drawing tube. The sequence is: B, total body length to tip of tentacles × width at greatest dimension; LE, length from posterior to eyes; SD, sucker diameter; PD, sucker peduncle diameter; PH, pharynx length × width; EA, excretory ampullae - length × width of left, then right, ampulla; E, diameter of left, then right, eye; AT, anterior testes - length × width of left, then right, testis; PT, posterior testes - length × width of left, then right, testis; S, shaft length × width at proximal end; I, introvert length × width.

The following other abbreviations are used:

Alc,100% ethanol; Bouin, Bouin's fixative; CP, cirrus preparation; deF, de Faure's mounting medium; E, East; Form, 10% formalin buffered to pH 7.0 with phosphate; Form-Acetic, Acetic-Formalin-Alcohol (AFA); H, Holotype, H&E, haematoxylin & eosin stain; HF, hot 10% Formalin; HW, hot water; Hx, Mayer's or Harris's haematoxylin stain; LS, longitudinal serial sections; NSW, New South Wales; NT, Northern Territory; P, Paratype; PP, pigment preparation; QLD, Queensland; QM, Queensland Museum; S, South; WA, Western Australia; WM, wholemount.

SYSTEMATICS

Order TEMNOCEPHALIDA
Family TEMNOCEPHALIDAE

Temnosewellia Damborenea & Cannon, 2001

TYPE SPECIES. *Temnosewellia minor* (Haswell, 1888) Damborenea & Cannon, 2001.

DIAGNOSIS. Temnocephalidae (Temnocephalinae) with 5 anterior tentacles, a posterior pedunculate adhesive disc, lacking conspicuous papillate ridges on tentacles or dorsal body, with dark (melanin?) pigment (if any) in body or eyes, with 5 syncytial plates: 1, tentacular; 2, a characteristic single, saddle-like post tentacular; 3, body; 4, peduncular; and 5, adhesive disc. Furthermore, the excretory pores lie on the body plate, outside the single, post-tentacular plate.

Other Australian species from *Cherax*:

Temnosewellia acirra sp.nov.

Temnosewellia chaeropsis (Hett, 1925) Damborenea & Cannon, 2001

Temnosewellia christineae sp. nov.

Temnosewellia dendyi (Haswell, 1893) Damborenea & Cannon, 2001

Temnosewellia punctata sp. nov.

Temnosewellia phantasmella sp. nov.

KEY TO SPECIES OF *TEMNOSEWELLIA* FROM AUSTRALIAN *CHERAX* SPP. CRAYFISH:

1. Lacking pigment except for eyes 2
   Dark pigment tracery on dorsal, and sometimes ventral, surface 3
2. Lacking any male sclerotic copulatory apparatus . . . . . *T. acirra* sp. nov.
   With sclerotic male copulatory apparatus bearing 1 or more large sharp spines at the base of the introvert . . . . . *T. dendyi*
3. Dense even pigment in blocks emphasising neural net, without posterior marginal glands . *T. christineae* sp. nov.
   Dorsal pigment a tracery; with posterior marginal glands 4
4. Marginal glands posterolateral only, from eastern Australia 5
   Marginal glands posterior, from WA 6
5. Pigment an open tracery, extending to tentacles; cirrus curved . . . . . *T. minor*
   Pigment very open, concentrated about excretory pores, not extending to tentacles; cirrus short and conical . . . . . *T. phantasmella* sp. nov.
6. Pigment decidedly clumped, most noticeable on body periphery and tentacles, several small glands along posterior body margin . . . . . *T. punctata* sp. nov.
   Pigment a dense tracery, two prominent, adjacent glands at posterior extremity of body . . . . . *T. chaeropsis*

Temnosewellia acirra sp. nov.
(Figs 1, 2)

Temnocephala sp. 2: Joffe & Cannon, 1998:3.

ETYMOLOGY. Latin, lacking a cirrus.

MATERIAL. HOLOTYPE: QMGL18689 (WM), ex *Cherax destructor*, dam, Eukey Qld (28°46.2'S 151°59.2'E) 18/Apr/1990, S.D. Cook, Form/Hx. PARATYPES: QMGL18690-18691 (WM); QMGL18693 (LS[1]), Condamine R., Warwick Qld (28°11.4'S 151°57.5'E) 24/Oct/1992, K.B. & S.G Sewell, Bouin/H&E; QMGL18702 (LS[2]), ex *Cherax destructor*, Bungil Ck. Roma (26°30'S 148°48'E) 2/Dec/1991, L.R.G Cannon & J.B. Jennings, Form/Hx; QMGL18710 (LS[3]),

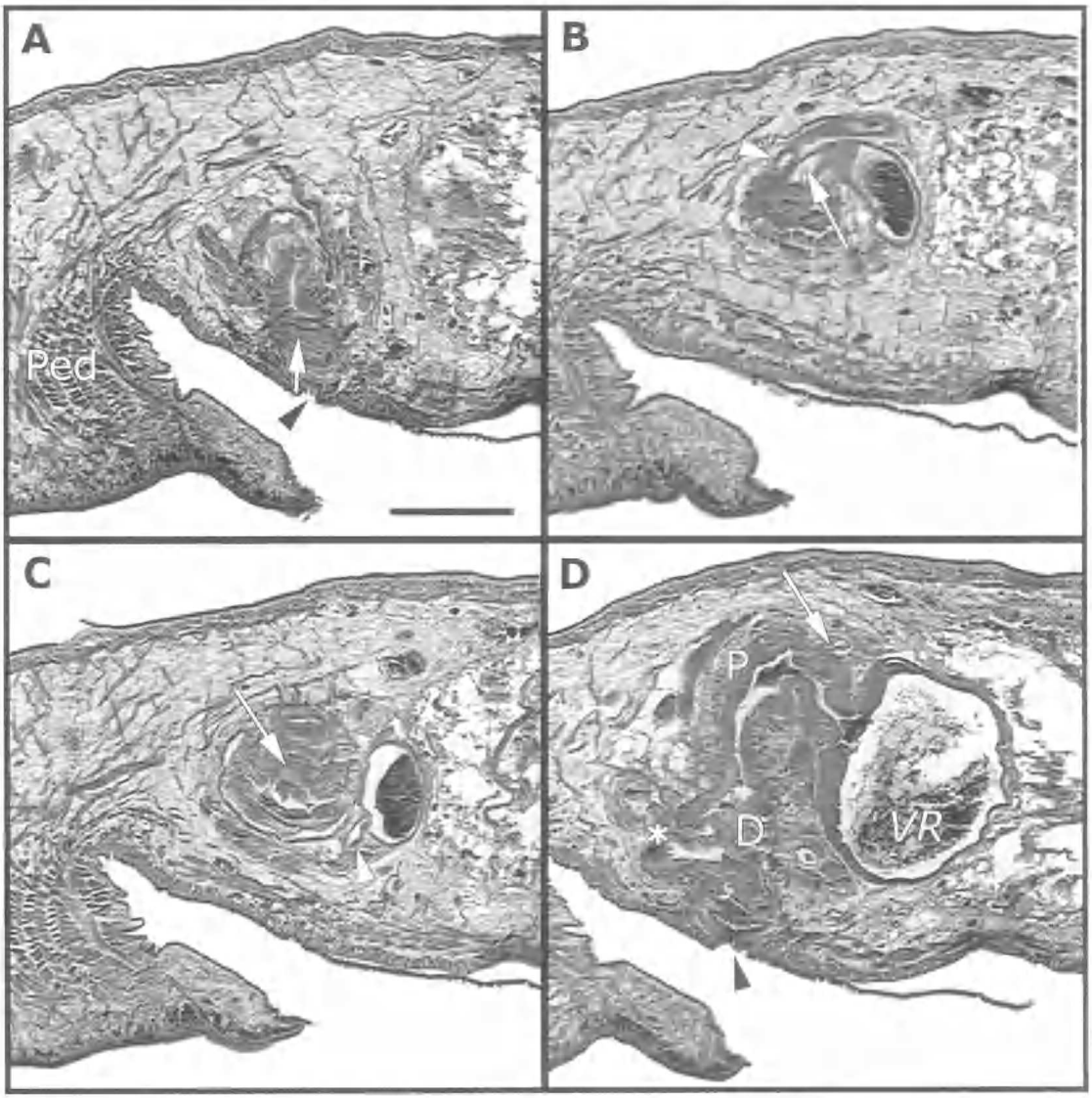

FIG.1. *Temnosewellia acirra*. Longitudinal section through genital region of QMGL18710. A-C, ♂. D, ♀. A, gonopore (arrow head), distal muscular 'penis' (arrow) and peduncle (Ped). B, junction of ejaculatory sac (arrowhead) with proximal copulatory bulb dorsal to the distal seminal vesicle junction (arrow). C, vas deferens (arrowhead) entering proximal seminal vesicle adjacent to copulatory bulb (arrow). D, from vesicula resorbens (*VR*) to gonopore (arrowhead). A muscular duct connects the vesicula resorbens to the proximal vagina (P) where the vitelline duct (arrow) enters. The proximal vagina is more muscular than the distal vagina (D) opens to the common atrium and blind caecum or copulatory bursa (*). Scale = 100μm.

12km SSE of Armidale (30°31'S 51°40'E) 26/Feb/1987, W. Higgins Form/H&E.

OTHER MATERIAL. Ex *Cherax destructor*. QLD: QMGL18711 (WM), Marlong Ck, Mt Moffat Nat. Pk (25°02'S 147°54'E), 26/Feb/1986, N.C. Monteith, 70% Alc/Hx; QMGL18703-18705 (WM), Willows gemfield, in dam beside road near Emerald (23°45'S 147°25'E 20/Oct/1990, S.D. Cook, HW/Form/Hx; QMGL18706 (LS[5]). HW/Form/H&E; QMGL18700-18701 (WM), Bungil Ck, Roma (26°30'S 148°48'E) 2/Dec/1991, L.R.G. Cannon & J.B. Jennings, Form/Hx; QMGL18695-18699 (WM), dam, Eukey (28°46.2'S 151°59.2'E) 18/Apr/1990, S.D. Cook, Form/Hx; QMGL18692 (LS[2]), HW/Form/H&E, same locality. NSW: QMGL18707-18708 (WM), 12km SSE of Armidale (30°31'S 51°40'E) 26/Feb/1987, W. Higgins Form/Hx; QMGL18709 (LS[3]), Form/H&E.

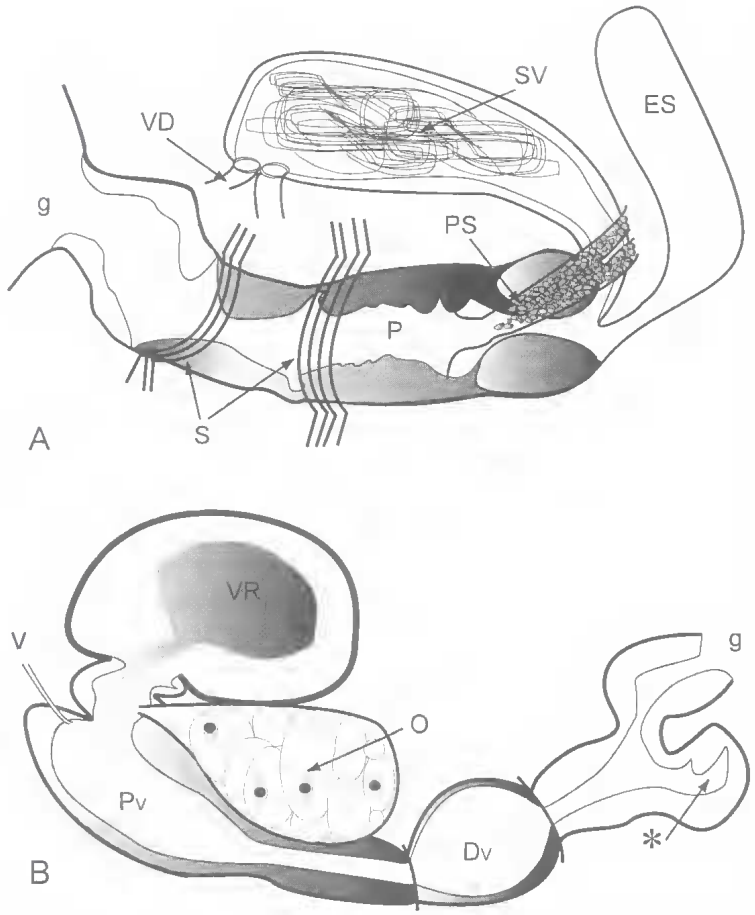

FIG. 2. *Temnosewellia acirra* copulatory structures. A, ♂; B, ♀. ES, ejaculatory sac; g, gonopore; P, muscular 'penis'; PS, prostate secretions; S, sphincter; SV, seminal vesicle; VD, vas deferens.

DESCRIPTION. *General Anatomy.* A medium sized, rather thick-bodied worm without body pigment except for two eyespots set close together. A small cluster of posterolateral glands present. Selected measurements are: QMGL18689 (H): B(1675x1041), LE(1302), SD(651), PD(385), PH(183x426), EA(89×59 & 89×59), ED(47 & 47); AT(266×219 & 296×237), PT(278×278 & 314×260); QMGL18690 (P): B(1858×1000), LE(1479), SD(657), PD(396); PH(195×473), EA(95×65 & 89×59), ED(41 & 41); AT(302×207 & 290×201), PT(284×284 & 308×266); QMGL18691 (P): B(1728×1087), LE(1361), SD(521), PD(308); PH(237×343), EA(101×77 & 112×71), ED(41 & 41); AT(225×148 & 278×178), PT(278×219 & 272×237).

Reproductive System. Female. No seminal receptacles, but a globular muscular duct lies between the vesicula resorbens and the top of the muscular vagina; vagina has a large proximal chamber and a smaller distal chamber with ridged walls, this opens via a sphincter into a female antrum which in turn passes to the common genital atrium which is voluminous and opens also to a caecum (bursa copulatrix).

Male. Testes with several large lobes when fully mature, anterior testis lies laterally at mid gut level, posterior testis at level of posterior of gut, seminal vesicle relatively thin walled, ejaculatory sac only slightly smaller, copulatory bulb, prostate without large reservoirs, totally lacking any sclerotic armature of male organ which consists of a muscular tube lined with a high epidermis; at the distal end is a sphincter and the duct opens to a large male antrum also lined with a high epidermis, a second sphincter lies at the mouth to the common genital atrium.

HOST. *Cherax destructor* (Parastacidae).

LOCALITY. Known from tributaries of the Murray Darling system draining westward from Armidale in central NSW north to the Carnarvon region of central Queensland.

REMARKS. This is the only species to lack a sclerotic stylus or cirrus. In some sections the muscular proximal tube is seen to push or evert into the male antrum and thus assume the role of a penis. Another unusual feature is the large bursa copulatrix or caecum opening from the common atrium. This worm lives in the branchial chamber, or nearby sheltered body regions, of *C. destructor* and alongside *Temnosewellia dendyi* which it superficially resembles in size and lack of pigment. *T. dendyi* has the following characters which serve to distinguish it from the new species: the pharynx is smaller, the posterior testis is set further back behind the gut and it has, apart from a prominent cirrus armed with a

distinctive central stylet, a longer and more muscular copulatory bulb in which prostate vesicles are aligned along the duct, and a muscular ejaculatory sac, which is not reflexed, opening via a wide mouth at the back of the copulatory bulb. In the female, there are 3-4 seminal receptacles. Furthermore, the rhabdite glands are fewer and larger.

Joffe & Cannon (1998: fig. 3E,J) identified and figured the epidermal mosaic of worms they identified as *Temnocephala* sp. 2 ex *Cherax destructor* from the Condamine R., Warwick. We can now formally identify these worms as *Temnosewellia acirra*.

Temnosewellia chaeropsis (Hett, 1925) Damborenea & Cannon, 2001
(Figs 3A,H, 5A, 6A)

Temnocephala chaeropsis Hett, 1925:569.

MATERIAL. Ex *Cherax tenuimanus*. WA: QMGL18717-18722 (WM), Inlet R., on South Western Highway to Walpole (34°55.2'S 116°34.2'E) 25/Jan/1992, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMG18716 (LS[1]); QMG217457 (CP), HW/Form/deF; QMG217499-217500 (CP); QMG217502 (CP); QMG217458 (PP); QMG217501 (PP); QMG217503 (PP).
Ex *Cherax* cf. *quinquecarinatus*. WA: QMGL18712-18715 (LS[1 each]), Inlet R., on South Western Highway to Walpole (34°55.2'S 116°34.2'E) 25/Jan/1992, L.R.G. Cannon & K.B. Sewell, HW/Form/H&E.

DESCRIPTION. *General Anatomy*. As described by Hett (1925), but with a fine tracery of pigment dorsally, becoming much less dense ventrally.

Reproductive System. Female. The female reproductive system has a distinctly bipartite vagina: distally globose and strongly muscular with a powerful distal sphincter, proximally narrow, with distinct seminal reeeptacles as described by Hett (1925, text-fig. 7).

Male. The cirrus is slightly curved (Fig. 5A), with a small, inconspicuous ejaculatory sac. Posterior gland reservoirs often contiguous (Fig. 3H). Selected measurements are: QMG217457: S(186×75); I(50×31); QMG217499: S(166×62), I(52x24); QMG217500: S(182×80), I(?×25); QMG217502: S(154×78), I(52×30).

HOSTS. *Cherax tenuimanus*, *C.* cf. *quinquecarinatus* (Parastacidae)

LOCALITY. Southwestern WA.

REMARKS. Originally known only from some preserved specimens conveyed to England. No types were designated, but the characteristic posterior gland reservoirs as two adjacent bulbs are quite distinctive. Hett (1925) said of *T. chaeropsis* that the entire animal showed no evidence of pigment (although they had been ' for some time in spirit'), but in sections dorsal pigment cells were apparent. Pigment is really quite extensive particularly dorsally. Furthermore, she said 'the penis, which is straight, has no terminal dilation', in fact the cirrus does curve slightly, though the introvert is hardly wider than the distal shaft. She claimed also 'there is no distinct ejaculatory sac': it is true that this sac is quite small and indistinct. Hett further remarked on the presence of seminal receptacles which she considered unique; in fact, Merton (1913) had described such structures from *Temnocephala rouxi*.

Hett (1925) commented extensively on the paired posterior glandular organs which she believed the distal ends of rhabdite glands (cf Hett, 1925, text-fig. 8 with Fig. 3H). Until Cannon (1993) and Cannon & Sewell (1995) described similar structures from other temnocephalans, *T. chaeropsis* was considered unique in having such glands. This led Cannon to incorrectly identify worms which were taken from WA marron, *Cherax tenuimanus*, cultured in South Africa, as *T. chaeropsis*. It has now been established that such glands are also found in *T. minor*, but have been overlooked (Cannon & Watson, 1996). Reports of *T. chaeropsis* from cultured marron in South Africa (Mitchell & Kok, 1988; Avenant-Oldewage,1993) are incorrect: the worms are *T. minor*.

Temnosewellia christineae sp. nov.
(Figs 3B, 5B, 6B)

ETYMOLOGY. In memory of Dr Christine Cannon.

MATERIAL. HOLOTYPE: QMGL18901 (WM), ex *Cherax depressus*, Gap Ck, Gap Ck Reserve picnic ground, Brookfield, Qld (27°28.7'S 152°55.7'E) Nov/1984, L.R.G. Cannon, AFA/Hx. PARATYPE: QMGL18902 (LS[7]); QMGL18903 (WM), 3/Sep/1984; Bouin/H&E.

OTHER MATERIAL. Ex *Cherax depressus*. QLD: QMGL18904-18905 (WM), Gold Coast (28°00'S 153°25'E), Dec/1983, L.R.G. Cannon, Form/Hx; QMGL18906-18907 (LS[3,3]), Bouin/H&E; QMGL18908-18918 (WM), gully near Capalaba (27°32'S 153°12'E) 22/Sep/1988, L.R.G.Cannon, AFA/Mayer's; QMGL18919-18921 (WM), Bouin/Hx; QMGL18922-18928 (LS[3,4,7,5,4,7,4]), Bouin/Hx; QMGL18929-18930 (WM), 19/Sep/1988, Alc/Hx; QMGL18931-18932 (WM), Winston Ck Rd, Sheldon (27°34'S 153°12'E), 18/Mar/1990; I. Forrester & L.R.G. Cannon, Form/Hx; QMGL18933 (LS[5]), Bouin/H&E;

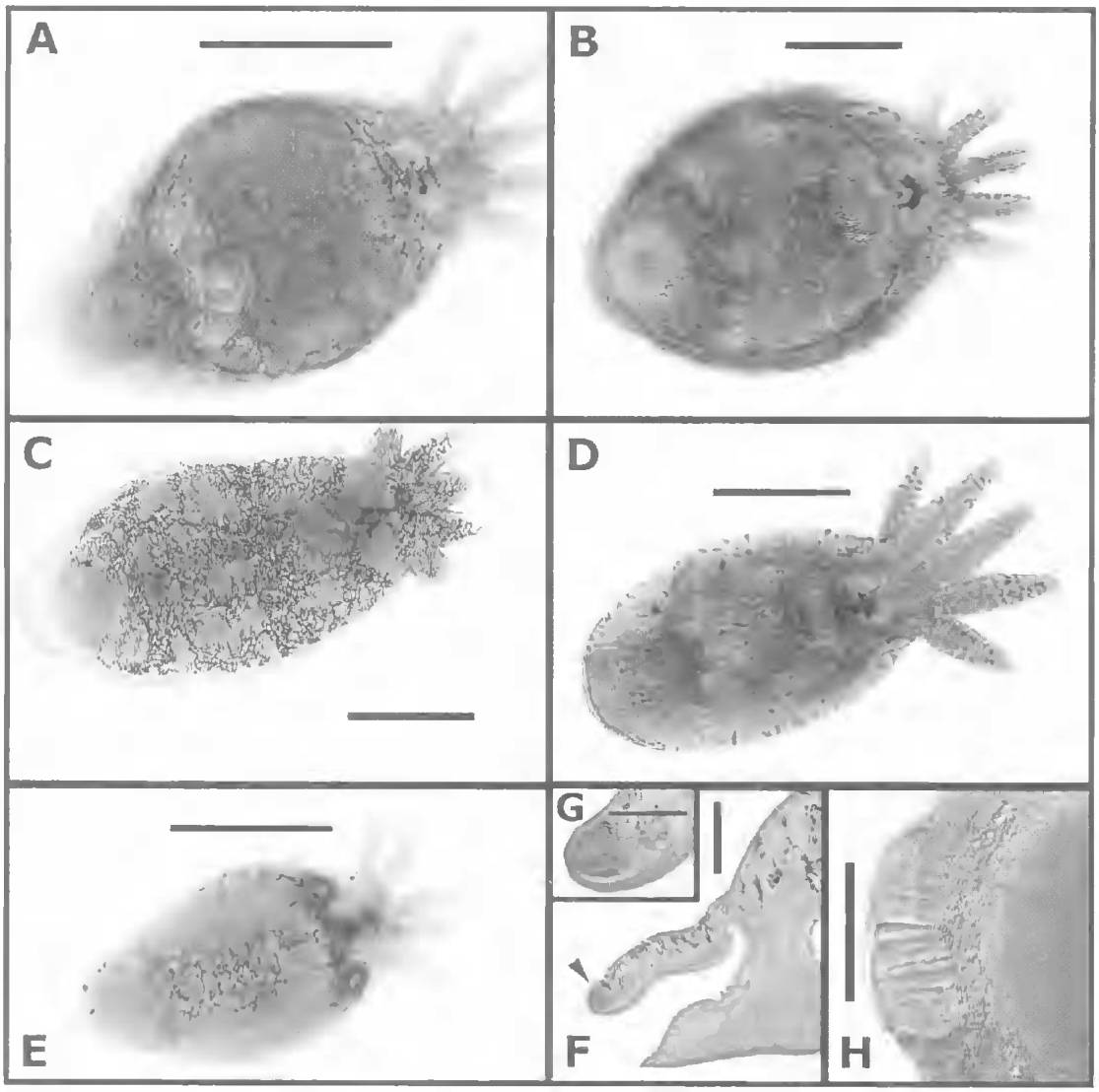

FIG. 3. *Temnosewellia* species showing pigment patterns (scales A-E= 500µm) and posterior glands (scales F and H = 100µm, scale G = 50µm). A, *T. chaeropsis* QMG217458; B, *T. christineae* QMG217467; C, *T. minor* QMGL18876; D, *T punctatus* QMG217471; E, *T. phantasmella* QMG217477; F, G, *T punctatus* QMGL18861; H, *T. chaeropsis* QMG217458.

QMGL18934-18937 (WM), Wallaby Ck, on Henderson Rd 0.2km from Mt Cotton Rd junction, Sheldon (27°34.2'S 153°12.8'E) 18/Mar/1990; L.R.G. Cannon, Form/Hx; QMGL18938-18939 (LS[9,7]), Bouin/H&E; QMGl 18940-18941 (WM), Gap Ck, Gap Ck Reserve picnic ground, Brookfield (27°28.7'S;152°55.7'E) Nov/1984, L.R.G. Cannon, AFA/Hx; QMGL18942 (WM), 2/Apr/1984, N. Hall; QMGL18943 (WM), Nov/1985, J. Jennings; QMGL18944-18945 (WM), Ithaca Ck (27°29'S;152°57'E) 22/Oct/1988, J. Short & L.R.G. Cannon, AFA/Hx; QMGL18946 (LS[5]), Bouin/H&E; QMGL18947-18948 (WM), gully on Mumford Rd, Narangba (27°12.1'S 152°57.3'E), 22/Apr/1990, J. Short & L.R.G. Cannon, AFA/Hx; QMGL18949 (LS[9]), Bouin*/H&E; QMG217459-217463 (CP), creek down stream from Kelly St crossing, Narangba (27°12'S 152°57'E) 19/Oct/1997, J.W. Short, HW/det; QMG217464-217467 (PP); QMGL18950-18951 (WM), Kroombit Ck, trib TA64 (24°22.9'S 150°59.8'E) 19/Sep/1990, L.R.G. Cannon & K.B. Sewell, HW/AFA/Hx; QMGL18952-18953 (LS[4,6]), Kroombit Ck, trib TA47 (24°22.2'S;150°58.5'E), 20/Sep/1990, L.R.G. Cannon & K.B. Sewell, Bouin/H&E; QMGL18954-18955 (WM), 20/Sep/1990, HW/AFA/Hx;

QMGL18956-18960 (WM), Kroombit Ck, Beauty Spot 98 (24°23'S 150°59'E), 21/Sep/1990; QMGL18961-18962 (LS[4,3]).
Ex *Cherax robustus*. QLD: QMGL18877-18878 (WM), Sunshine Ck, Sunshine Beach (26°24.5'S 153°06.5'E) 16/Apr/1990, J.W. Short & L.R.G. Cannon, AFA/Hx; QMGL18880 (WM); QMGL18882 (WM); QMGL18879 (LS[20]); QMGL18881 (LS[2]); QMGL18883-18885 (LS[8,2,2]), Bouin/H&E.

DESCRIPTION. *General Anatomy*. A medium sized worm with a distinctive pigment pattern dorsally appearing as a series of blocks emphasising the neural network. Selected measurements are: QMGL18901 (H): B(3650× 1635), LE(2336), SD(633), PD(314); PH(521×432), EA(207×112 & 230×112), ED(65 & 65); AT(432×284 & 432×161), PT(336×263 & 373×260); QMGL18903 (P): B(1796×1460), LE(1460), SD(509), PD(314); PH(350×321), EA(201×160 & 189×142), ED(65 & 77); AT(260×166 & 272×160), PT(284×172 & 337×172).

Reproductive System. Female. The vesicula resorbens leads through a short tube and is joined by the ovary, four small seminal receptacles and the vitelline duct before opening to a muscular vagina with a prominent distal sphincter at the entrance to a commodious common atrium.

Male. Swollen vasa deferentia enter separately a seminal vesicle so reduced as to resemble no more than a thickened ejaculatory canal. It and the ejaculatory sac, which is large, enter the base of the cirrus side by side together with the prostate gland ducts: there is no obvious copulatory bulb. Selected measurements are: QMG217459: S(468×86); I(77x31); QMG217460: S(337×59), I(75×30); QMG217461: S(465×80), I(77×3?); QMG217462: S(468×145), I(75×28); QMG217463: S(479×109), I(74×30).

HOSTS. *Cherax depressus* and *C. robustus* (Parastacidae).

LOCALITY. Known from SEQ and Kroombit Tops CEQ.

REMARKS. Potentially confused with *T. minor*, but the pigment pattern is much more regular. This pattern is reminiscent of that illustrated by Haswell (1893) of a young *T. fasciata* (Haswell, 1888) from crayfish now recognised as *Euastacus* spp. Furthermore, the cirrus of *T. christineae* is at least twice as long with a more oval introvert when inverted than that of *T. minor*. This cirrus is not dissimilar to that illustrated by Haswell (1893: pl. XIII, fig. 14) as a variant of *T. fasciata*, though we now know that a great diversity of worms occur on these crayfish (Cannon & Sewell, 1994).

Small and large specimens of this worm swim using rapid dorso-ventral movements of the body and tentacles: it is the only temnocephalan known to swim.

Temnosewellia dendyi (Haswell, 1893) Damborenea & Cannon, 2001 (Figs 5C, 6C)

Temnocephala dendyi Haswell, 1893:135.

MATERIAL. Ex *Cherax albidus*. VIC:QMGL18748 (WM), creek on Mathison Rd, 6km S of Winchelsea (38°15'S 143°59'E), 30/Sep/1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMGL18749 (LS[2]), HW/Form/H&E.
Ex *Cherax destructor*. QLD: QMGL18723-18724 (WM), Bungil Ck, Roma (26°30'S 148°48'E) 3/Dec/1986, L.R.G. Cannon & J.B. Jennings, Form/Hx; QMGL18725-18727 (LS [5,6,8]), AFA/H&E; QMGL18728-18729 (WM), 2/Dec/1986; QMGL18730 (LS[2]), AFA/H&E; QMGL18731 (WM), Western R. 1.5km from Winton on Jundah Rd. (22°24.2'S 143°02.2'E) 22/Sep/1990, S.D. Cook, 70% Alc/Hx; QMGL18732 (LS[4]), Willows gemfield in dam beside road (23°45'S 147°25'E) 20/Sep/1990, S.D. Cook, 70% Alc/H&E; QMGL18733 (WM), dam at Eukey (28°46.2'S 151°59.2'E) 18/Apr/1990, S.D. Cook, 70% Alc/Hx; QMGL18734-18736 (WM), Accommodation Ck, near Bald Mountain (28°52.9'S 151°53.7'E) 10/Apr/1990, L.R.G.Cannon & K.B.Sewell, HW/AFA/Hx; QMGL18737 (LS[3]), HW/AFA/H&E; QMGL18738-18740 (LS[1,1,1]), Condamine R., Warwick (28°11.4'S 151°57.5'E) 24/Oct/1992, K.B. & S.G. Sewell, Bouin/H&E; QMG217489-217493 (CP), 4/Aug/1994, K.B. Sewell & B.I. Joffe HW/deF; QMG217494-217495 (CP), 25/Jun/1996, K.B. Sewell, R.D. Adlard & R.D. Sewell; QMGL18900 (WM), creek by Marlborough Caravan Park, Marlborough (22°49.2'S 149°53.2'E), L.R.G. Cannon & K.B. Sewell, 20/Sep/1990, HW/AFA/Hx. NSW: QMGL18741-18743 (WM), Lake Madgwick, UNE campus, Armidale (30°31'S 151°40'E) 23/May/1991, Zoology Dept. UNE, Bouin/Hx; QMGL18744 (LS[3]), Yarunga Ck tributary, 1.2km NW Fitzroy Falls Morton NP. (34°38.4'S 150°28.4'E) 19/Oct/1991, L.R.G. Cannon & K.B. Sewell, Bouin/H&E. SA: QMGL18750-18751 (WM), Kangaroo I. (35°50'S 137°15'E) 11/Aug/1995, S. Nichols, Form/Hx; QMGL18752 (WM), Coopers Ck (27°44'S 140°15'E) 26/Nov/1988, I. Beveridge, Form-Acetic/Hx; QMGL18753 (WM), Bool Lagoon (37°09'S 140°43'E) 15/Nov/1988, I. Beveridge, Form-Acetic/Hx; QMGL18754 (WM), Mt Jagged, 9/Feb/1988, I. Beveridge, Form-Acetic/Hx; QMGL18755 (WM), Lake Merretti (34°01'S 140°46'E), 3/Dec/1988, I. Beveridge, Form-Acetic/Hx; QMGL18756 (WM), The Narrows via Clayton (29°17'S 138°23'E), 2/Dec/1988, I. Beveridge, Form-Acetic/Hx; QMGL18757-18758 (WM), Mt Benson

((37°02'S 139°49'E) 18/Oct/1988, I. Beveridge, Form-Acetic/Hx; QMGL18759 (WM), Lake Alexandrina (35°25'S 139°10'E) 20/Jan/1989, I. Beveridge, Form-Acetic/Hx; QMGL18760 (WM), Bordertown (36°18'S 140°46'E) 31/Oct/1988, I. Beveridge, Form-Acetic/Hx. VIC: QMGL18745-18746 (WM), creek on road to Ballan 15km S of Daylesford (37°21'S 144°09'E) 6/Oct/1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMGL18747 (LS[2]), HW/Form/H&E.
Ex *Cherax robustus*. QLD: QMG217496, G218301 (CP), trackside pond on McMahon Rd , Bribie I. (27°02.5'S 153°10.3'E) 31/Jan/1995, K.B. Sewell, L.R.G. Cannon, Z. Kalil & J. Short HW/deF.
Ex *Cherax depressus*. QLD: QMG217487-88 (CP), Wallaby Ck, Sheldon, 27/Sep/1994, K.B. Sewell, B.I. Joffe, I. Solovei & S. Solovei, HW/deF.

DESCRIPTION. *General Anatomy*. Largely as described by Haswell (1893). Moderately large and without pigment except for the eyes.

Reproductive System. Female. Vesicular resorbens opening to duct into which open 4 seminal receptacles along with ovary and vitelline duct. Vagina reflexed proximally, muscular with distal sphincter. Common atrium large with a small posterior caecum (bursa copulatrix).

Male. The vasa deferentia enter the seminal vesicle separately; the seminal vesicle has narrow distal region surrounded by massed prostate glands which enter the base of the copulatory bulb, their ducts continuing parallel to the ejaculatory duct. Selected measurements are: ex *Cherax depressus*, QMG217487: S(194 × 75), I(93 × 19); QMG217488: S(158 × 95), I(93 × 22); QMG217489: S(260 × 118), I(101 × 27); QMG217490: S(182 × 62), I(96 × 25); QMG217491: S(274 × 139), I(101 × 27); QMG217492: S(271 × 104), I(92 × 21); QMG217493: S(259 × 96), I(95 × 22); QMG217494: S(243 × 98), I(90 × 18); QMG217495: S(158 × 52). I(98 × 19); ex *Cherax robustus* QMG217496: S(192 × 58), I(99 × 19); QMG217497: S(183 × 75), I(99 × 24).

HOST. *Cherax destructor*, *C. albidus* and *C. robustus* (Parastacidae).

LOCALITY. Known from the Murray-Darling system in Qld., NSW, Vic. and SA, but also from coastal Qld and Kangaroo Is.

REMARKS. This and *T. acirra* may co-inhabit the branchial chamber and nearby protected locations on the principal host, *Cherax destructor*. The worms are of similar size and since both lack pigment can be superficially confused (see remarks on *T. acirra* above). The details of the cirrus of specimens from different hosts and from widely separated regions are very similar (Figs 5C, 6C show the cirri of worms from *Cherax depressus* and *C. robustus* are indistinguishable from those from *C. destructor* well illustrated by Haswell (1893: pl. 12, fig. 7).

The pattern of the mosaic of *T. dendyi* ex *Cherax destructor* from the Condamine R. Warwick was described and figured by Joffe & Cannon (1998: figs 2J; 4A-C).

Joffe & Cannon (1998) identified worms close to *T. dendyi* from *Cherax dispar* and *C. depressus* from Wallaby Creek, Sheldon and described the epidermal mosaic as identical to that of *T. dendyi*: these worms were *T. dendyi* (Fig. 5Ci).

Temnosewellia minor (Haswell, 1888)
Damborenea & Cannon, 2001
(Figs 3C, 4, 5D, 6D)

Temnocephala minor Haswell, 1888:284; Haswell, 1893:134.

MATERIAL. Ex *Cherax albidus*. SOUTH AFRICA: QMGL18854-18855 (WM) between Dardanap and Lowden on Patterson Rd (in culture), 6/Sep/1991, H.J. Schoonbee, Form/Hx; QMGL18856 (LS[2]) Form/H&E.
Ex *Cherax depressus*. QLD: QMGL18963-18966 (WM), Gold Coast, (28°00'S 153°25'E), Dec/1983, L.R.G. Cannon, Form/Hx; QMGL18967-18968 (LS[2,2]), Form/H&E; QMGL18969 (WM), gully near Capalaba, (27°32'S 153°12'E) 22/Sep/1988, L.R.G. Cannon, AFA/Hx; QMGL18970-18972 (WM), Bouin/Hx; QMGL18973-18975 (LS[1,2,3]), Form/H&E; QMGL18976-18977, 18985-18988 (WM), Wallaby Ck., on Henderson Rd 0.2km from Mt Cotton Rd junction, Sheldon (27°34.2'S 153°12.8'E) 18/Mar/1990, I. Forrester & L.R.G. Cannon, Form/Hx; QMGL18983 (WM), AFA/Hx; QMGL18984 (WM), Bouin/Hx; QMGL18978-18982 (LS[2,3,3,3,3]), Form/H&E; QMG217478-217479 (CP) 22/Sep/1994, K.B. Sewell, B.I. Joffe & I.V. & S. Solovei, HW/deF; QMGL18989 (LS[3]), Winston Rd, Sheldon (27°34'S 153°12'E) 18/Mar/1990, I. Forrester & L.R.G. Cannon, AFA/H&E; QMGL18990 (WM) Gap Ck, Gap Ck Reserve picnic ground, Brookfield, (27°28.7'S 152°55.7'E) Nov/1984, J. Jennings, Form/Hx; QMGL18991 (LS[2]), Form/H&E; QMGL18992 (WM), creek by Marlborough Caravan Park, Marlborough (22°49.2'S 149°53.2'E), L.R.G. Cannon & K.B. Sewell, 20/Sep/1990, Form/Hx.
Ex *Cherax destructor*. QLD: QMGL18762-18763 (LS[2,2]), Western R., 1.5km from Winton on Jundah Rd (22°24.2'S 143°02.2'E) 22/Sep/1990, S.D. Cook, 70% Alc/H&E; QMGL18764 (LS[1]), Thompson R. at Longreach waterhole. (23°24.7'S 144°13.8'E) 2/Oct/1990, L.R.G. Cannon & K.B. Sewell, HW/Form/H&E; QMGL18765-18767 (WM), in dam beside road, Willows gemfield (23°45'S 147°25'E) 20/Sep/1990, S.D. Cook, 70% Alc/Hx; QMGL18768-18770 (LS[1,2,2]), 70% Alc/H&E; QMGL18771 (WM), Marlong Ck, Mt Moffat NP (25°02'S 147°54'E), 26/Sep/1986, N.C. Monteith, 70% Alc/Hx; QMGL18772 (LS[4]), 70% Alc/H&E; QMGL18773 (WM), Dawson R. Taroom (25°39'S 149°48'E) 3/Dec/1986, L.R.G. Cannon

& J.B. Jennings, Form/Hx; QMGL18774 (LS[3]), Form/H&E; QMGL18775-18777 (WM), Bungil Ck, Roma (26°30'S 148°48'E), 2/Dec/1991, L.R.G. Cannon & J.B. Jennings, Form/Hx; QMGL18780-18781 (LS[2,2]), Form/H&E; QMGL18778-18779 (LS[2,3]), 3/Dec/1991, Bouin/H&E; QMGL18782 (WM), Wilson R. at Noccundra, W of Thargomindah (27°49'S 142°35'E) 17/Apr/1990, G.B. Monteith, 70% Alc/Hx; QMGL18783-18784 (LS[1,1]), Condamine R., Warwick (28°11.4'S 151°57.5'E) 24/Oct/1992, K.B Sewell & S.G. Sewell, Bouin/H&E; QMGL18785-18786 (WM), Feb-Mar/1993, L.R.G.Cannon, silver nitrate; QMG217481-217482 (CP), 4/Aug/1994, Sewell & B.I. Joffe, HW/deF; QMG217483 (CP) 1/Sep/1994, K.B. Sewell; QMG217484 (CP) 25/Jun/1996, K.B. Sewell; R.D. Adlard & R.D. Sewell; QMG217485-217486 (PP); QMGL18787-18788 (WM), dam at Eukey (28°46.2S 151°59.2'E) 17/Apr/1990, S.D.Cook, 70% Alc/Hx; QMGL18789-18791 (LS[4,3,3]), 70% Alc/H&E. NSW: QMGL18804 (WM), Lake Madgwick, UNE campus, Armidale (30°31'S 151°40'E), 26/Feb/1987, W. Higgins, Bouin/Hx; QMGL18805-18807 (WM) 23/May/1991, Zoology Dept. UNE; QMGL18808 (LS[4]), Bouin/H&E; QMGL18809-18811 (WM), Yarunga Ck trib., 1.2km NW Fitzroy Falls Morton NP. (34°38.4'S 150°28.4'E), 19/Oct/1991, L.R.G.Cannon & K.B.Sewell, HW/Form/Hx; QMGL18812-18813 (LS[4,3]), Bouin/H&E; QMGL18814-18818 (WM), trib. of Murrumbidgee R. on Nanangro Rd, near Childowlah, outside Yass (34°51'S 148°55'E), 16/Oct/1991, L.R.G.Cannon & K.B.Sewell, HW/Form/Hx; QMGL18819 (LS[3]), HW/Form/H&E. VIC: QMGL18820 (WM), creek on Mathison Rd. 6km S of Winchelsea (38°15'S 143°59'E) 30/Sep/1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMGL18821 (LS[3]), HW/Form/H&E. SA: QMGL18822 (WM), Cowell (33°41'S 136°55'E) 8/Dec/1988, I. Beveridge, Form-Acetic/Hx; QMGL18823 (WM), Lake Merreti (34°01'S 140°46'E), 3/Dec/1988; QMGL18824 (WM), Avenue Ra. (37°05'S 140°18'E), 18/Oct/1988; QMGL18825 (WM), Onkaparinga R. (35°00'S 138°49'E) 22/Feb/1988; QMGL18826 (WM), Murray R., Murray Bridge (35°07'S 139°16'E) 10/Feb/1989; QMGL18827 (WM), Lake Alexandrina (35°25'S 139°10'E) 20/Jan/1989; QMGL18828 (WM), Inman R. (35°30'S 138°31'E) 19/Nov/1988; QMGL18829 (WM), Bordertown (26°18'S 140°46'E) 31/Oct/1988; QMGL18830-18831 (WM), Mt Benson (37°02'S 139°49'E), 18/Oct/1988; QMGL18832 (WM), Bool Lagoon (37°09'S 140°43'E), 15/Nov/1988.

Ex *Cherax dispar*: QLD: QMG217480 (CP) Wallaby Ck, on Henderson Rd, 0.2km from Mt Cotton Rd junction, Sheldon (27°34.2'S 153°12.8'E) 22/Sep/1994, K.B. Sewell, B.I. Joffe & I.V. & S. Solovei HW/deF; QMGL18792-18794 (WM), Woodgate Lagoons (25°07.4'S 152°30.6'E) 6/Apr/1991, K.B.Sewell, Form/Hx; QMGL18795 (WM) 18/Sep/1990, L.R.G. Cannon & K.B.Sewell, Form/Hx; QMGL18796 (WM), Form/unstained.

Ex *Cherax quadricarinatus*. QLD: QMGL18761 (WM), Deception Bay (in culture) (27°10'S 153°05'E) 22/Oct/1986, B.Herbert, Form/Hx.

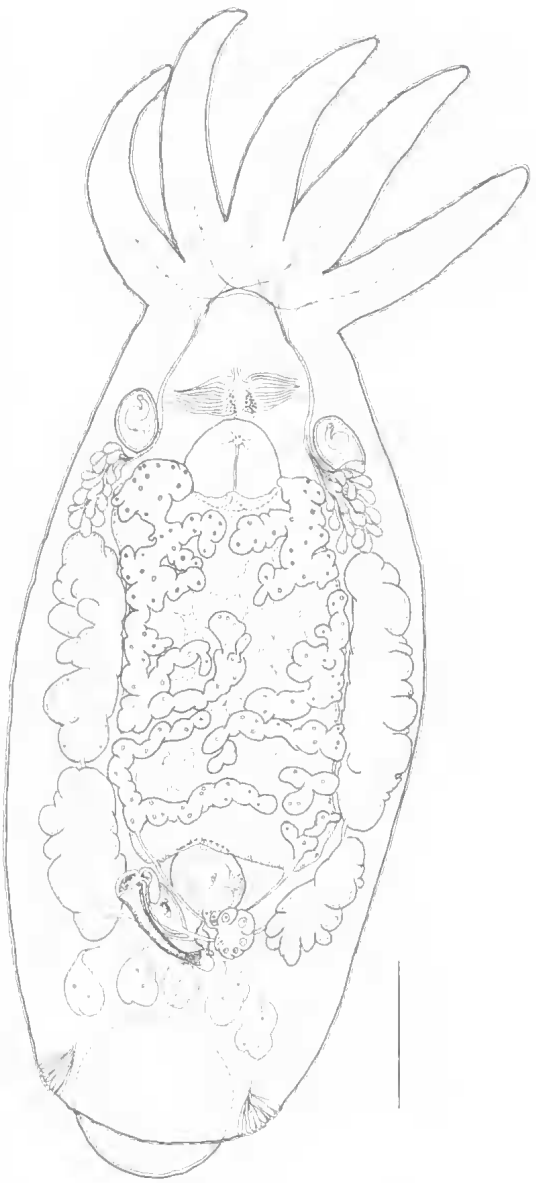

FIG. 4. *Temnosewellia minor*. Scale = 500µm.

Ex *Cherax tenuimanus*. QLD: QMGL18797-18801 (WM), Ipswich (in culture) (27°37'S 152°47'E) 12/Oct/1982, L.R.G. Cannon, Form/Hx; QMGL18802-18803 (WM), Esk (in culture) (27°14'S 152°25'E) 28/Sep/1982, L.R.G. Cannon, Form/Hx. SA: QMGL18833 (WM), Parilla (in culture) (35°18'S 140°40'E) 11/Oct/1988, I. Beveridge, Form-Acetic/Hx. WA: QMGL18834 (WM), Inlet R., SW hwy. to Walpole (34°55.2'S 116°34.2'E) 25/Jan/1992, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMGL18835-18836 (WM),

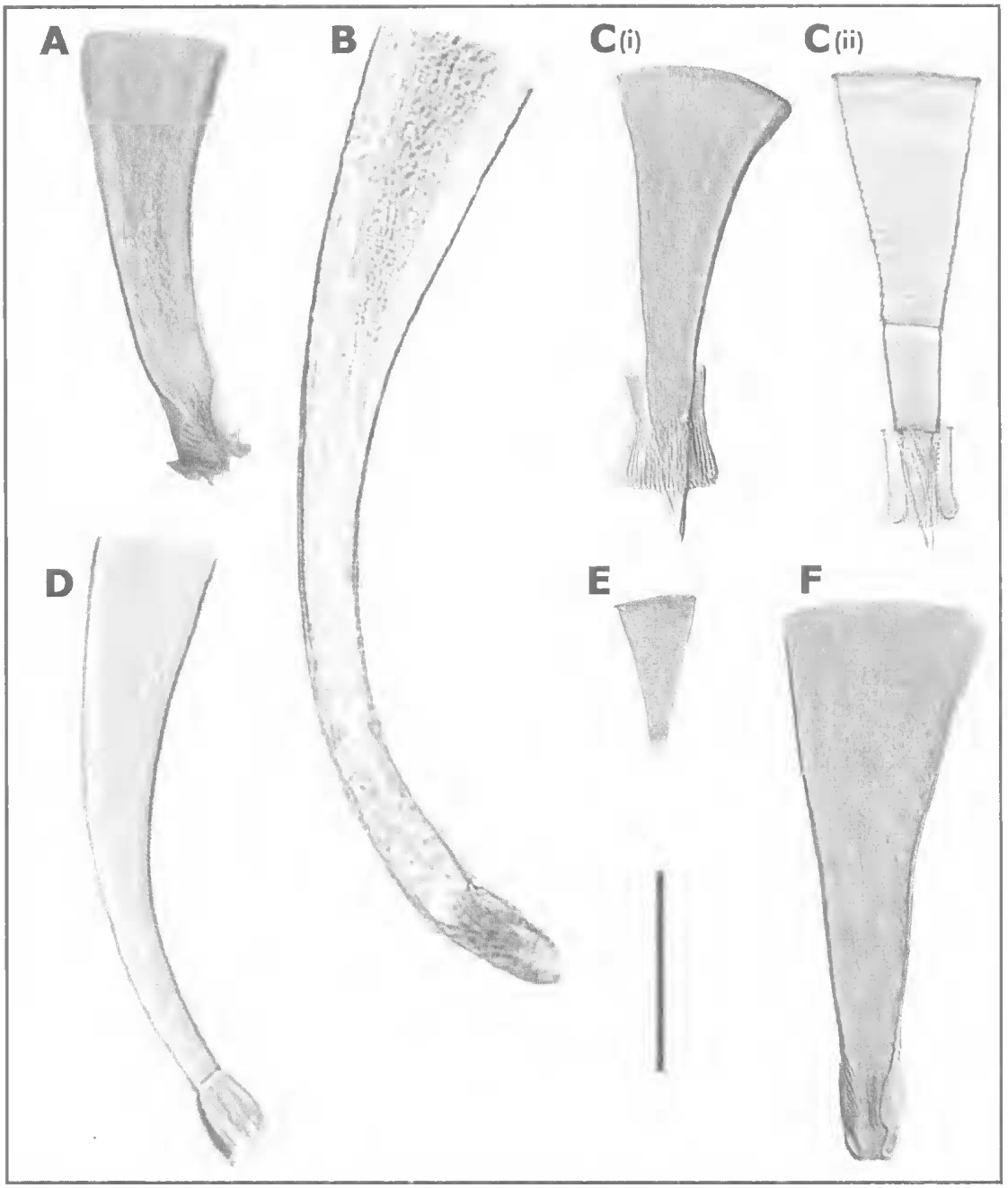

FIG. 5. Nomarski interference contrast photomicrographs of De Faure's preparations of the whole cirri of *Temnosewellia* species. A, *T. chaeropsis* QMG217457. B, *T. christineae* QMG217462. C, *T. dendyi* - (i) QMG217488 ex *Cherax depressus*, (ii) QMG217497 ex *C. robustus*. D, *T. minor* QMG217482. E, *T. phantasmella* QMG217475. F, *T. punctatus* QMG217469. Scale = 100µm.

Dam near Byford (32°13'S 116°00'E), 22/Feb/1990, L. Evans, Form/Hx; QMGL18837-18838 (LS[3,2]), Form/H&E; QMGL18839-18840 (WM) WA Fisheries, Fish Health Dept., 6/Aug/1991, T. Thorne, Form/Hx; QMGL18841-18844 (LS[2,2,2,1]), Form/H&E; QMGL18845 (WM) Western Australia, Nov/1989, L.Evans, Form/Hx; QMGL18846-18847 (LS[1,1]), Form/H&E; QMGL18848-53 (WM) Margaret R. Marron

Farm, 10km S Margaret R. (34°00.8'S 115°09.5'E) 23/Jan/1992, L.R.G. Cannon & K.B. Sewell. Form/Hx. SOUTH AFRICA: QMGL18868-18872 (WM) (in culture), 1991, A. Avenant-Oldewage, Form/Carmine; QMGL18873-18875 (WM) (in culture), 1982, D.J. Kok, Form/Carmine.

DESCRIPTION. *General Anatomy*. Medium sized temnocephalan with pigment dorsally very variable but usually with some open patches (Fig. 3C): it extends forward from the eyes mainly into the proximal or basal regions of the central 3 tentacles; ventral pigment only a tracery to about the level of the mouth. Although they can be overlooked, clusters of posterolateral glands occur (Cannon & Watson, 1996).

Reproductive System. Female. Vesicula resorbens opens to a muscular chamber and then to the relative short muscular vagina with a powerful sphincter distally before opening to the common atrium. No evident seminal receptacles.

Male. Testes deeply notched on lateral borders, not generally overlapping. Cirrus gently curved with introvert only slightly inflated. Selected measurements are: QMG217478: S(93×67), I(25×19); QMG217479: S(98×58), I(33×19); QMG217480: S(72×52), I(34×22); QMG217481: S(305×89), I(34×18); QMG217482: S(294×61), I(37×18); QMG217483: S(343×70), I(41×15); QMG217484: S(58×21), I(40×19).

HOSTS. *Cherax destructor*, *C. dispar*, *C. depressus* and, in culture, *C. albidus*, *C. quadricarinatus* and *C. tenuimanus* (Parastacidae).

LOCALITY. Found in the whole of the Murray-Darling system Qld, NSW, Vic and SA, and also coastal Queensland from Marlborough south where *Cherax depressus* and *C. dispar* occur. Found on cultured and free range marron, *C. tenuimanus*, in WA and elsewhere where this crayfish is cultured, notably Japan (Oki, Tamura, Takai & Kawakatsu, 1995) and South Africa. This worm has been found also on European crayfish presumably contaminated in aquaria holding Australian crayfish (Xylander, 1997), but now is believed to have escaped into streams in Bavaria, Germany (Xylander, pers. comm.).

REMARKS. Haswell (1888, 1893) clearly characterised this species. No types exist, but there seems little possibility now of confusion about the identity of this worm which is so common and widespread. The most striking difference or discrepancy with the original accounts (Haswell, 1888,1893) is the presence of postero-lateral glands (Cannon & Watson, 1996). These glands do not stain consistently and can easily be overlooked. *T. minor* is now known to be the worm infecting cultured marron in South Africa. It appears to have a catholic choice of hosts and obviously may become widespread.

Reports of this species from *Cherax punctatus* by Cannon & Jennings (1987) should be referred to *C. depressus*.

Details of the cirrus are essentially as presented by Haswell (1893) as can be seen from the de Faure's preparation (Fig. 5D; 6D). We observed no more than minor differences in proportions in specimens from different localities. Furthermore, our specimens mostly resemble Haswell's (1893, pl. 15, fig. 1) regarding the distribution of the testes i.e. they are clearly separated and not overlapping as his text states (though with equivocation). The pattern of the mosaic of *T. minor* ex *Cherax destructor* from the Condamine R., Warwick was described and figured by Joffe & Cannon (1998: figs 2C,F-G, 3C).

Temnosewellia punctata sp. nov.
(Figs 3D,F,G, 5F, 6F)

ETYMOLOGY. In reference to the punctate coalescence of the dorsal pigment.

MATERIAL. HOLOTYPE: QMGL18857 (WM), ex *Cherax* cf. *quinquecarinatus*, Carbunup R., 2km N of Carbunup at railway bridge, WA (33°40.8'S 115°11.8'E) 23/Jan/1992, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx. PARATYPES: QMGL18858-18859 (WM); QMGL18860-18861 (LS[1,3]), HW/Form/H&E.

OTHER MATERIAL. Ex *Cherax* cf. *quinquecarinatus*. WA: QMGL18862-18863 (WM), Carbunup R., 2km N of Carbunup at railway bridge (33°40.8'S 115°11.8'E) 23/Jan/1992, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMGL18864 (LS[2]), HW/Form/H&E; QMG217468-217469 (CP) HW/70% Alc/deF; QMG217497 (CP); QMG217470-217471 (PP); QMG217498 (PP).
Ex *Cherax tenuimanus*. WA: QMGL18865-18867 (WM), at catchment weir, Margaret R. (33°57.0'S 115°05.2'E), 23/Jan/1992, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx.

DESCRIPTION. *General Anatomy*. Medium sized temnocephalan with distinctive pattern of pigment with punctiform clusters (Fig. 3D). Posterior gland reservoirs numerous and spread in a wide arc along the posterior margin of the body. Selected measurements are: QMGL18857 (H): B(1432×858), LE(1314), SD(414), PD(166); PH(225×260), EA(142×77 & 178×77), ED(41 & 47); AT(189×130 & 237×124), PT(237×118 & 243×160); QMGL18858 (P): B(1686×746),

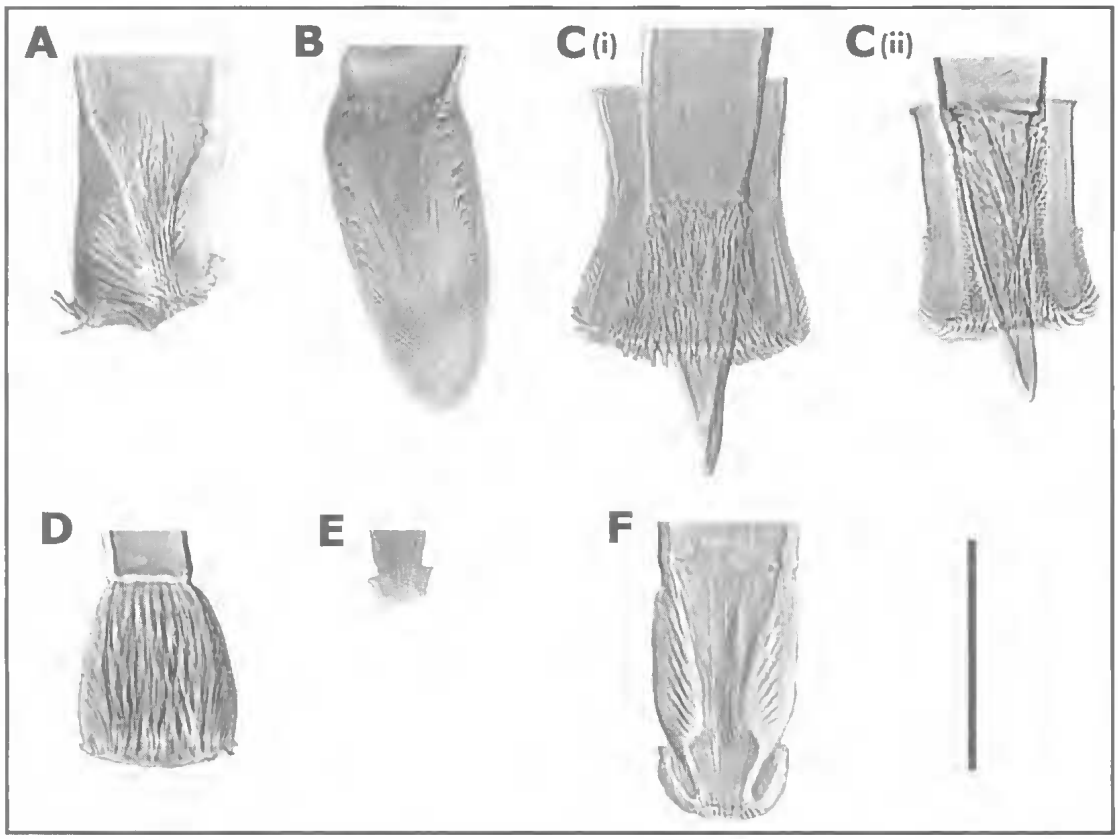

FIG. 6. Nomarski interference contrast photomicrographs of De Faure's preparations of the introverts of cirri of *Temnosewellia* species. A, *T. chaeropsis* QMG217457. B, *T. christineae* QMG217462. C, *T. dendyi* - (i) QMG217488 ex *Cherax depressus*, (ii) QMG217497 ex *C. robustus*. D, *T. minor* QMG217482. E, *T. phantasmella* QMG217475. F, *T. punctata* QMG217469. Scale = 50 μm.

LE(1065), SD(367), PD(142); PH(294×254), EA(89×65 & 89×65), ED(36 & 36); AT(124×112 & 154×101), PT(219×130 & 195×130); QMGL18859 (P): B(1941×805), LE(1219), SD(385), PD(148); PH(195×278), EA(101×71& 95×77), ED(47 & 47); AT(189×118 & 183×118), PT(231×130 & 219×136).

Reproductive System. Female. Vesicula resorbens with 4 small seminal receptacles at its base; ovary joins below these at the top of a long, narrow, proximal vagina which enters an extremely voluminous and highly muscular distal vagina. This in term opens via a strong distal sphincter to a small common atrium.

Male. A moderately small ejaculatory sac joins the top of the cirrus bulb with the prostate glands and the ejaculatory duct. Cirrus gently curved with slightly inflated introvert (Fig. 6F). Selected measurements are: QMG217468: S(222×93), I(72×31); QMG217469: S(223×100), I(70×30); QMG217497: S(164×62), I(75×30).

HOSTS. *Cherax* cf. *quinquecarinatus* and *C. tenuimanus* (Parastacidae)

LOCALITY. Southwestern WA.

REMARKS. This species most closely resembles *T. chaeropsis* with which it shares not only the posterior gland reservoirs, but also the large and muscular distal vagina which clearly must serve as an ootype or uterus. The most striking differences are the pigment pattern which in this species is distinctively punctate, not a tracery, and the much smaller, but more numerous and more broadly distributed posterior gland reservoirs.

Temnosewellia phantasmella sp. nov.
(Figs 3E, 5E, 6E)

ETYMOLOGY. Latin, from *phantasma* = a spirit; literally a little spirit from the appearance of the pigment pattern.

MATERIAL. HOLOTYPE: QMGL18893 (WM), ex *Cherax rhynchotus*, Lake Wicheura, Cape York, Qld (10°46'S 142°34'E) 27/Sep/1990, P.J.F. Davie & J.W.Short, 70% Alc/Hx. PARATYPES: QMGL18894-18895 (WM); QMGL18891-18892 (LS[1,2]), Alc/H&E.

OTHER MATERIAL. Ex *Cherax rhynchotus*. QLD: QMGL18889 (WM), Lake Wicheura, Cape York, (10°46'S 142°34'E) 27/Sep/1990, P.J.F. Davie & J.W.Short, Alc/Hx; QMGL18896 (WM); G217472-217475 (CP) Alc/deF; QMG217476-217477 (PP); QMGL18890 (LS[2]), Lake Boronto, near Somerset, Cape York (10°45'S 142°35'E) 25/Sep/1974, G.B. Monteith, Alc/H&E.

DESCRIPTION. *General Anatomy*. Small slender worm with eyes set very close together and a distinctive pigment pattern concentrated anteriorly leaving lacunae about excretory ampullae. Pharynx robust and sucker set well posterior: prominent postero-lateral glands. Selected measurements are: QMGL18893 (H): B(1609×337), LE(680), SD(148), PD(71); PH(130×124), EA(59×41 & 53×41), ED(24 & 24); AT(118×107 & 136×107), PT(142×77 & 136×89); QMGL18894 (P): B(840×320), LE(562), SD(148), PD(77); PH(83×77), EA(41×36 & 41×36), ED(18×18); AT(118×59 & 118×65), PT(83×59 & 83×65); QMGL18895 (P): B(746×266), LE(485), SD(130), PD(53); PH(107×59), EA(41×36& 41×30), ED(18 & 18); AT(95×53 & 77×59), PT(65×53 & 71×65).

Reproductive System. *Female*. The vesicula resorbens opens to a short muscular vagina and then to a large common atrium with a low epithelium.

Male. Seminal vesicle large and ejaculatory sac a small bulb enter the base of the cirrus side by side: no evident copulatory bulb. Selected measurements are: QMG217472: S(79×45), I(16×12); QMG217473: S(72×34), I(15×11); QMG217474: S(64×29), I(16×11); G217475: S(76×43), I(17×12).

HOST. *Cherax rhynchotus* (Parastacidae)

LOCALITY. Known only from Cape York, Queensland.

REMARKS. This small worm is characterised by a cirrus dramatically smaller than in any other *Temnosewellia* from *Cherax*. Its closest relative appears to be *T. butlerae* known from the freshwater crab, *Holthuisana transversa,* taken from Augathella, western Queensland. However, the pigment pattern is dissimilar: in *T. phantasmella* there is an anterior concentration spreading laterally and surrounding the excretory ampullae as two clear lacunae, but in *T. butlerae* there is a small concentration before the eyes and then a straggling tracery in about 3 longitudinal bands. The eyes in *T. butlerae* are set farther apart, the common atrium has very well developed epithelium and the seminal vesicle and ejaculatory sac are slender. Furthermore, the hosts and localities are very different.

Temnosewellia sp.

MATERIAL. Ex *Cherax punctatus*. QLD: QMGL18886 (WM), Dingo Ck near Traveston (26°19'S 152°47'E) Mar/1973, S.R. Monteith, Alc/Hx; QMGL18887 (LS[2]), Alc/H&E.

DESCRIPTION. A small and apparently eyeless species.

REMARKS. The single specimen QMGL18886 cannot be readily referred to another species. The host crayfish is a deep burrowing one and may therefore rarely emerge. An eyeless species of worm from a host that rarely emerges into daylight is thus not unexpected. Haswell (1893) reported the eyes to be 'very small' in *T. engaei* (Haswell, 1893) from the burrowing land crayfish *Engaeus fossor* from Gippsland. Similarly, the temnocephalans reported from the burrowing isopod *Phreatoicopsis terricola*, *T. caeca* (Haswell, 1900) and *T. geonoma* (Williams, 1980), are blind and without pigment.

Teratological specimens of temnocephalans without eyes, however, are sometimes encountered, but usually can be readily placed. It is not possible to describe this species formally as there is far too little material and we are reluctant to infer too much about the absence of eyes in one specimen.

DISCUSSION

Cannon & Sewell (1995) showed that subtle differences in male copulatory structures can indicate species separation in temnocephalans (*Craspedella spenceri* and *C. simulator*); such differences are not readily apparent within *Temnosewellia*, e.g. *T. minor*. We recognise, however, that only a thorough meristic study from live preparations using de Faure's fluid would reveal such differences. Furthermore, life history and ecology of *Temnosewellia* spp. suggests no more than regional variations will be

found: these worms are active external dwelling worms which colonise new hosts much more readily than do species of *Craspedella* which are found in the sheltered branchial cavity and consequently show higher host specificity. Clearly the two WA species of *Temnosewellia* are close as would be expected. Low host specificity is particularly manifest, however, with *T. minor* which has the potential to spread around the world.

The worms *T. acirra* and *T. dendyi* which occur predominantly in the sheltered branchial habitat of *Cherax destructor* may be shown to exhibit niche separation or competition. This matter needs investigation, for the two species were confused from live study: only a microscopic examination of the male copulatory structures can distinguish them.

Questions arise concerning the recent biogeography of *T. minor* from *C. dispar* and *C. depressus*. *T. minor* is widespread in the Murray Darling system and has been translocated around the country and the globe in aquaculture. Its occurrence on the two small *Cherax* from coastal Queensland seems to indicate a recent intermingling of streams across the watershed of the Great Dividing Range. Musyl & Keenan (1992) suggested this as an explanation for some freshwater fish in central Queensland being found on both sides of the divide, i.e. from both the western Warrego and coastal Dawson drainages. *T. minor* could have spread south from here along the coast to include both *C. dispar* and *C. depressus* as hosts: molecular techniques may be able to indicate when this may have happened. On the coast, *T. christineae* appears the ecological homologue to *T. minor*. Is competition between these species evident?

Other Australian species currently in *Temnocephala s. l.* and found, for example, on crabs, shrimps and crayfish have also been tentatively assigned to *Temnosewellia* by Damborenea & Cannon (2001), pending more thorough review. Further, the eyeless worm specimen from *C. punctatus*, a rarely encountered burrowing crayfish with a limited distribution, is likely to prove a new species (other eyeless species are known), but more specimens are needed to rule out any teratology.

The exclusion of *T. rouxi* from this account is tentative. Though previously known only from Aru Is. (Indonesia), Cannon (1991) reported it from cultured red-claw (*Cherax quadricarinatus*) from the NT. It and *Temnocephala semperi* Weber, 1889 from Asian freshwater crabs may belong to a separate, as yet undescribed, genus (B.I. Joffe, pers. comm.).

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